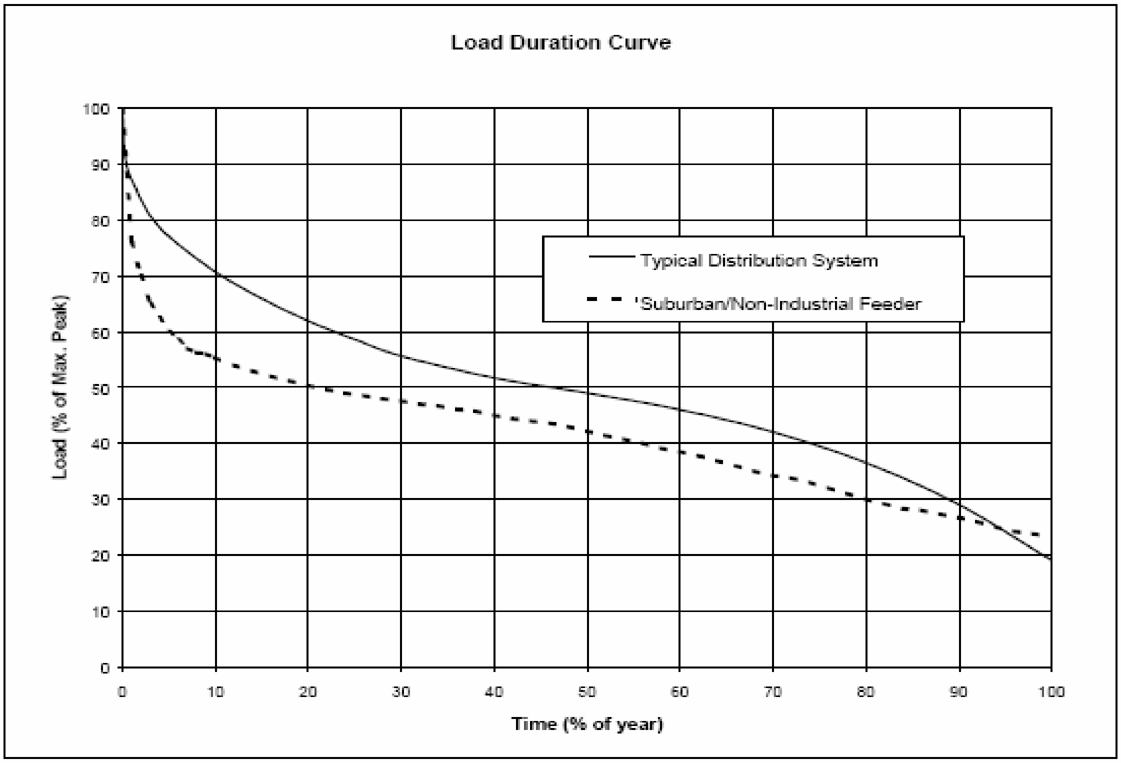
Information Request CLF-SEBANE-1-1

Refer to Mr. Greene's testimony, p. 3. Please explain in more detail the benefits of distributed generation, and in particular photovoltaics, in a) distribution system planning and possible Transmission and Distribution (T&D) cost deferral, and b) grid reliability and security. Please include copies of any studies that support your conclusions.

Part (a)

As load on an electric distribution system grows, eventually a point is reached when the load exceeds the capacity of one or more components of the power system, such as a transformer or distribution line (feeder). The traditional response by a utility to this situation is to install additional capital equipment to relieve the overloading. An overloaded distribution system poses much greater risks that key components will fail, leading to outages, power quality problems, and increased operations and maintenance costs over the long term. The installation of DG systems can provide an alternative way to alleviate capacity deficiencies, as well as reap additional operational, environmental, and power quality benefits. Because photovoltaic output is closely correlated with system peaks (discussed below) PV installations can be a very effective way of deferring or avoiding traditional distribution system investments.

A load duration curve is a useful way to depict constraints on a distribution system. A load duration curve shows the percentage of time during a year that the load on a feeder is above a certain capacity level. A typical load duration curve for a distribution feeder is shown below. The load duration curve begins at maximum loads and declines steadily to the right, eventually showing the minimum loads. The load duration curve for a typical feeder reveals that load reductions (or additional capacity) in relatively few hours, can prevent overloading. As loads grow over time, the number of critical hours when capacity is strained will also grow.



Source: *Distributed Utility Integration Test,* National Renewable Energy Lab, 2003

Two illustrative load duration curves are shown above: the solid line depicts a "typical" overall distribution system with a mix of residential, commercial and industrial loads; the dotted line depicts the load duration characteristics of a feeder that is primarily residential and commercial with a minimal industrial component -- a characteristic that is increasingly common for many feeder lines in suburban areas. The feeder shows a significant peaking profile: only 1 percent of hourly loads exceed 80% of capacity and only 3 percent of hourly loads exceed 70% of capacity.

To defer capacity upgrades (such as new transformers) it is not necessary for DG to provide baseload generation – the ability to offset demand during the relatively few peak hours is the key. Ideally, a utility would review its distribution system periodically and identify key feeders and substations with fast-growing load or poor utilization that could benefit from DG deployment in a cost-effective manner. Unfortunately, this practice is not widespread within the utility industry, nor does it appear to have been institutionalized to date within NSTAR's planning and operating practices.

The addition of DG resources, and particularly PV, will tend to reduce peak demands and flatten the load duration curve. However, NSTAR states that its distribution system planning is unaffected by DG, since it assumes that its distribution capacity must be sufficient regardless of whether the installed DG operates or not. [Lamontagne testimony,

p. 30, lines 4-5). DG provides an important source of load diversity (among other potential sources of load diversity) for the many customers served on a given feeder. Overlooking demonstrable and verifiable reduction of peak demand by DG located on a particular feeder is a recipe for over-investment in traditional distribution plant, and unnecessary costs for ratepayers.

One familiar misconception about the ability of PV to defer/avoid distribution plant relates to its intermittence. While PV is intermittent, it is closely correlated with utility system peaks. The reason is not surprising: in summer months, air conditioning load (resulting from high temperatures and high humidity) is strongly influenced by insolation levels.

Demonstration projects have given empirical support to theories surrounding system benefits from PV. The Kerman PV plant on the Pacific Gas & Electric (PG&E) system is the first and largest plant designed and built to measure the benefits of grid-support photovoltaics. The benefits created by this plant are detailed in the study attached as CLF-SEBANE-1-1 (a).

Please see the following attachment:

a. Attachment CLF-SEBANE-1-1 (a), Brian Farmer, Howard Wenger, Thomas Hoff, and Charles Whitaker, *Performance And Value Analysis of the Kerman 500kW Photovoltaic Power Plant*

Part (b)

The Council on Foreign Relation's recent report on terrorism *America Still Unprepared — America Still in Danger* noted, "an adversary intent on disrupting America's reliance on energy need not target oil fields in the Middle East. The homeland infrastructure for refining and distributing energy to support the daily lives of Americans remains largely unprotected to sabotage." Two critical weaknesses identified in the report pertaining to energy infrastructure are electric transmission networks and natural gas pipelines. Among the study's recommendations is that the U.S. should "fund a stockpile of modular backup components to quickly restore the operations of the energy grid should it be targeted."

Distributed generation technologies are exactly the remedies sought by the Council on Foreign Relations: they are modular, highly reliable, and can operate independent of the grid if configured to do so. Photovoltaic DG goes one better, since it is not dependent on a potentially vulnerable fuel supply to generate power.

Photovoltaics are a proven and dependable distributed renewable energy source, especially with regard to unplanned outages and catastrophic events. PV is extremely versatile, and can be deployed anywhere to meet local needs. Some examples:

- Electricity Grid Security: Since the early 1980s, electric utilities have used PV in a variety of grid and non-grid applications. PV has been used to power remote data relaying stations critical to the operation of supervisory control and data acquisition (SCADA) systems used by electric and gas utilities. PV/battery hybrids are a proven and preferred alternative to using grid power, which must be stepped down to voltage levels used by the communications and security equipment – and may not even be available during an emergency situation.
- The blackout of 2003, and the loss of cellular service for millions of Americans, made the vulnerabilities of grid power for telecommunications abundantly clear. The demand for small power plants for digital wireless and broadband local loop service is growing at roughly 8% per year. Given the large number of cellular sites and remote terminals, this market could grow to several GW of PV demand, coupled with battery storage. Similar needs would extend to the traffic lights, street lighting, and the signal market.
- The need for energy self-sufficiency at emergency centers, water pumping stations, wastewater treatment facilities, fuel filling stations is obvious, yet few have this capability; today. Grid connected PV systems, with battery backup could be the solution. Large end-users with mission critical needs may also be attracted to PV in combinations with battery storage or dispatchable DG to better withstand outages resulting from to terrorism, system malfunctions, or other mishaps

Please see the following attachments:

b. Attachment CLF-SEBANE-1-1 (b), Peter F. Varadi, Gerald W. Braun, *The Security Photovoltaic Market (SPV)*

c. Attachment CLF-SEBANE-1-1 (c), Council on Foreign Relations, *America Still Unprepared — America Still in Danger*

Information Request CLF-SEBANE-1-2

Refer to Mr. Greene's testimony, p. 3. Please explain in more detail the benefits of distributed generation, and in particular photovoltaics, in Clean Air Act compliance and the attainment of regional climate change policy goals. Please include copies of any studies that support your conclusions.

Response

Photovoltaics have no air emissions associated with their use and are thus considered a non-emitting electric generation technology of great value in meeting Clean Air Act requirements, as well as emerging concerns (and potential future regulations) regarding greenhouse gases (GHGs). It is precisely for these reasons that state and federal air quality officials have recommended various incentives to encourage additional renewable energy production, including that from photovoltaics. For example, under the Clean Air Amendments of 1990, Congress established a set-aside of sulfur dioxide allowances for qualifying renewable energy and energy efficiency technologies, with included photovoltaics. More recently, EPA has issued guidance documents to states implementing the NOx SIP Call (which affects 22 states east of the Mississippi) that between 5 and 15% of the NOx allowances at a state's disposal should be earmarked for energy efficiency and renewable energy (EE/RE) projects. The Massachusetts DEP currently has a proposed regulation under review that would implement the EPA's recommendations.

Similar to environmental rules relating to central power plants, various regulatory agencies, including the Massachusetts DEP, are proposing to make DG emission standards much more stringent. The DEP has conducted preliminary discussions with stakeholders, and is expected to issue a proposed emissions rule in the next few months. By all indications, the rule is likely to bring DG emission standards much closer to traditional "Best Available Control Technology" principles, typically applied for new central power plants. Significant reductions in NOx, particulates, and carbon monoxide are expected when the DEP finalizes the emission rules.

The actual air quality benefits relating to DG units (including photovoltaics) will depend on several factors including: (1) what are the emissions of the electric generators "at the margin" which are displaced when photovoltaic units produce energy; (2) where are the displaced central generation units relative to the distributed generation facilities; (3) how will increasing market penetration of DG system affect long-term investments in central station plants; and (4) will the installation of DG systems include related energy issues such as retirement or derating of existing boilers or bundled energy efficiency measures?

Please see the following attachment:

a. Attachment CLF-SEBANE-1-2 (a), The Regulatory Assistance Project, *Model Regulations for the Output of Specified Air Emissions from Smaller-Scale Electric Generation Resources*

Information Request CLF-SEBANE-1-3

Refer to Mr. Greene's testimony, pp. 8 – 12. Please calculate the emissions that would be avoided by the DG systems modeled.

Response

The *2002 NEPOOL MARGINAL EMISSION RATE ANALYSIS* provides emission rates for SO_2, NOx, and CO_2 per MWh, by season, and by peak/off-peak in the given day.

2002 Marginal Emission Rates (Lbs./MWh)

Emission	On-Peak Ozone Season	Off-Peak Ozone Season	On-Peak Non-Ozone Season	Off-Peak Non-Ozone Season	Annual Average
SO_2	3.68	2.00	4.88	2.99	3.27
NO_X	1.37	0.76	1.51	1.01	1.12
CO_2	1,412.2	1,170.6	1,535.6	1,299.5	1,337.8

A simple calculation can show how these emission rate are used for the illustrative 200 kW PV installation described in my testimony. As noted in the testimony, the PV system produces 255,547 kWh annually. Using the annual average emission rates in the NEPOOL report (for simplicity), the avoided emissions are:

SO_2	837	lb
NOx	286	lb
CO_2	342,477	lb

For the GenSet which produces 1,557,512 kWh per year (also described in my testimony) the avoided emission calculation is as follows:

SO_2	5,094	lb
NOx	1,745	lb
CO_2	2,084,292	lb

However, there would also be emissions from the GenSet. Assuming the use of a 200 kW gas Microturbine, the total emission would be (see CLF-SEBANE-1-2 (a), Appendix B)

SO_2	12	lb
NOx	686	lb
CO2	2,486,568	lb

The net emissions reduction (increase) for the GenSet:

SO_2	5,082	lb
NOx	1,059	lb
CO2	(402,276)	lb

It should be noted that the marginal emission rates found in the annual NEPOOL report continues to decline each year due to the increasing use of combined cycle gas-fired plants, increasingly stringent emissions standards for new and existing plants, and the slow retirement of older units that typically have higher emissions.

Although it is infrequently noted, emission comparisons between DG and central power plants should also take into account transmission- and distribution-related line losses, which are typically in the range of 5 to 10 percent, depending on location-specific factors.. Because DG output is located at or very close to the point of end use, line losses are de minimus. The net result is that to serve 1 MWh of end-user electrical load, the DG units would need to produce 1 MWh of power, while the central station plant would need to produce between 1.052 and 1.11 MWh of power, with additional emissions relating to the incremental busbar power needed to serve the customer's 1 MWh of load.

Please see the following attachment:

a. Attachment CLF-SEBANE-1-3 (a), NEPOOL Environmental Planning Committee, *2002 NEPOOL Marginal Emission Rate Analysis*

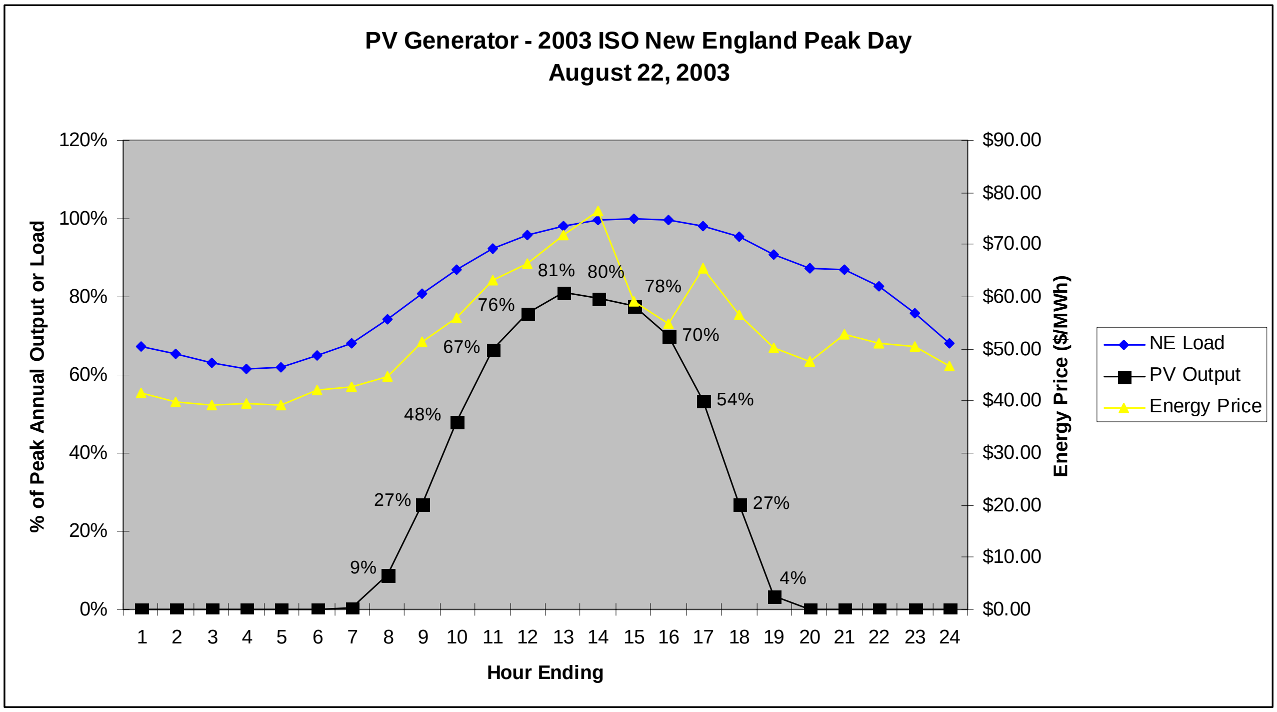


Figure 1: PV Customer Generation; New England Load & Market Prices
August 22, 2003

<u>Information Request CLF-SEBANE-1-4</u>

Refer to Mr. Greene's testimony, p. 23. Please explain in more detail the statement that although photovoltaic electricity is an intermittent power source, it is closely correlated with system peaks, providing valuable energy and capacity when it is often most critical to the needs of the grid.

<u>Response</u>

One familiar misconception about the ability of PV to defer/avoid distribution plant relates to its intermittence. While PV is intermittent, it is closely correlated with utility system peaks. The reason is not surprising: in summer months, air conditioning load (resulting from high temperatures and high humidity) is strongly influenced by insolation levels. Figure 1 below, illustrates this point. This graph plots the output of a Massachusetts-based photovoltaic generator relative to New England system loads, and hourly clearing prices, during the 2003 system peak of 24,573 MW reached on August 22, 2003.

The high correlation between generation and load is called effective load-carrying capacity (ELCC). ELCC is the ability of a power generator—whether PV or conventional—to effectively contribute to meeting a utility's capacity needs during peak hours. ELCC describes the percentage of nameplate capacity that is typically available from a resource during utility peak hours. In summer-peaking systems, such as NSTAR's, where air conditioning load is the key variable driving system peaks and is closely correlated with insolation, PV has a high ELCC. The ELCC in Massachusetts ranges between 40-60 percent The ELCC may be interpreted in terms of ideal resource equivalence; e.g., a 100 MW PV plant with a 60% ELCC may be considered as equivalent to a 60 MW fully dispatchable unit with no down-time.

Information Request CLF-SEBANE-1-5

Refer to Mr. Greene's testimony, pp. 24 – 25. Please explain the rationale for the various exemptions that are described.

Response

"Test 1: Has the distribution utility experienced a loss of at least 10% of its gross revenues relating to the installation and use of on-site generation? If not, all on-site generators are exempt from the standby rates consistent with the test delineated in Ch. 164, §1G(g) of the imposition of exit fees. "

As noted in my response to Information Request NSTAR-SEBANE-1-19, the reference in my testimony to G.L. c. 164, §1G(g) and its provisions for recovery of "exit fees" from on-site generators was presented for the purpose of demonstrating that the Legislature has previously considered the question of utility revenue erosion relating to on-site generators and established parameters that should, at the very least, be instructive in this proceeding. If the utility has not reached the threshold noted above, my proposal would provide the DG customer an elective exemption from the standby rate.

"Test 2: Is the standby generator larger than 60 kW? If so, the first 60 kW would be automatically exempt from any standby rate, similar to the exiting exemption afforded net-metering customers who are 60 kW or less, under 220 CMR 11.04(7)(c)."

This proposed exemption recognizes that all DG owners are automatically entitled to net metering if their DG installation is 60 kW or less and would thereby be exempt by existing regulation from any standby charges. The intent of this provision is to mitigate some of the bias against larger-size DG systems that may result from the imposition of a standby charge for non net-metered customers, and to do so in a way that treats all DG installations equitably. Larger scale DG installations are the ones that tend to drive DG costs down for the benefit of the broader market. This provision will help enable larger DG systems to continue to play this vital role

"Test 3: Is the DG generator an MTC eligible resource? If so, the customer is exempt."

This provision recognizes that in the Electric Restructuring Act of 1997, M.G.L. c. 40J, §4E(f) the Legislature instructed the Massachusetts Technology Park Corporation to promote specific renewable and distributed generation technologies for the benefit of the Commonwealth and its residents. This policy objective was sufficiently important to the Legislature that it expressly established a ratepayer funding mechanism to support investments in these technologies. Given this legislative backdrop, it would be counterproductive for standby rates that may be adopted in this proceeding to impede the market adoption of the technologies clearly sought by the Legislature.

"Test 4: Is the DG generator a non-emitting resource? If so, the customer is exempt."

As noted in response to CLF-SEBANE-1-2, DG technologies have the potential to provide significant air quality benefits, and promote the attainment of various state and federal air quality standards. Non-emitting DG, to the extent not already covered under one of the other elective exemptions, should certainly be out of harm's way if a standby charge emerges from this proceeding. The term "non-emitting resource" pertains specifically to distributed generation facilities that do not produce gaseous emissions containing criteria pollutants, air toxics, or greenhouse gases during the production of electrical energy.

"Test 5: Is the average output of the DG system during 15 – minute demand-interval peaks less than 20% of the metered demand levels used for billing purposes? If so, the customer is exempt."

This provision is intended to recognize that there are numerous reasons that a customer's use of distribution capacity can change over time, and that, if a standby charge is to be imposed, such changes relating to DG must be significant and outside the normal ebb and flow of the customer's demand. For example, a customer's use of distribution capacity can change for many reasons that are NOT subject to the standby charge: weather-related conditions, the business cycle, the installation of energy efficiency measures, fuel switching, etc. The suggested 20% threshold is intended to limit any DG-related standby changes to a level where they would begin to exceed other routine (and accepted) sources of load volatility.